WATER ELECTROLYTIC APPARATUS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a water electrolytic apparatus used mainly for producing hydrogen.

DESCRIPTION OF THE RELATED ART

As such an apparatus, a conventional water electrolytic apparatus is disclosed in Japanese Patent Application Laid-open No.6-33283.

A general water electrolytic apparatus has an electrode area of around hundred square centimeters. If the water electrolytic apparatus is operated at a current density of 1 A/cm^2, electric current of several hundred amperes is required, leading to inevitable loss in ohm and the extreme thickening of a cable. The thus-required large electric current also leads to a reduction in efficiency of the converter, for example, in the case where a DC/DC converter is mounted at an upstream side of an input electric power. To produce the same amount of hydrogen avoiding these problems, it is necessary to decrease the electrode area (if the current density is fixed at 1 A/cm^2, the area is reduced to 1/4, and the current is reduced to 1/4), and to increase the number of the water electrolytic cells (if the area is reduced to 1/4, the number of the water electrolytic cells is increased four times produce the same amount of hydrogen).

However, if a plurality of water electrolytic cells are laminated as in the prior art, there is a limit in number of cells laminated. As the area of the water electrolytic cell is reduced and the number of the water electrolytic cells is increased, it is more difficult to maintain uniform performances. When a water electrolytic apparatus having a power supply is formed by combining a water electrolytic apparatus of a laminated structure, for example, with a panel-shaped solar cell, the following problem is encountered: When the water electrolytic apparatus and the solar cell are superposed one on another from the demand for the compactness, the height of the entire system is increased and hence, the entire system is not suitable to be placed on a roof or the like.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a water electrolytic apparatus of the above-described type, which is of a thin type, wherein an increase in electric current is inhibited, and even when it is superposed on a panel-shaped solar cell, the height of the entire system can be suppressed to a low level.

To achieve the above object, according to the present invention, there is provided a water electrolytic apparatus comprising a plurality of water electrolytic cells each having a solid polymer electrolyte membrane, an anode, and a cathode, the anode and the cathode being arranged on opposite sides of the electrolyte membrane, respectively, the water electrolytic

cells being developed on a hypothetical plane and electrically connected in series to one another.

With the above arrangement, an increase in electric current can be inhibited in the water electrolytic apparatus. In addition, it is possible to ensure that the thickness of the water electrolytic apparatus is substantially equal to the thickness of the water electrolytic cells, whereby the thinning of the water electrolytic apparatus can be achieved. Therefore, if the water electrolytic apparatus is superposed on a panel-shaped solar cell, the height of the entire system can be suppressed to a lower level.

The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a plan view of a plurality of electrolytic cells in a state in which they have been developed in a single hypothetical plane;

Fig.2 is an enlarged sectional view of an embodiment of a water electrolytic apparatus, taken along a line 2-2 in Fig.1;

Fig.3 is an exploded perspective view of the embodiment of the water electrolytic apparatus;

Fig.4 is a plan view of another embodiment of a water electrolytic apparatus; and

Fig.5 is an exploded perspective view of the another

embodiment of the water electrolytic apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described by way of embodiments with reference to the accompanying drawings.

Referring to Figs.1 to 3, a water electrolytic apparatus 1 includes a plurality of water electrolytic cells 2 which are developed in one hypothetical plane and electrically connected in series to one another.

Each of the water electrolytic cells 2 is of a rectangular parallelepiped shape as a whole and has a laminated structure. As best shown in Fig.2, the water electrolytic cell 2 has a solid polymer electrolyte membrane 3 (for example, Nafion made by du Pont de Nemours. E.I., and Co.) having a proton conductivity at a central portion thereof. An current collector 5 having a seal member 4 around its outer peripheral edge and a plate-shaped anode 7 likewise having a seal member 6 around its outer peripheral edge are disposed sequentially on an upper surface of the membrane 3. On the other hand, an current collector 9 having a seal member 8 around its outer peripheral edge and a plate-shaped cathode 11 likewise having a seal member 10 around its outer peripheral edge are disposed sequentially on a lower surface of the membrane 3. A catalyst layer 12 containing iridium (Ir) is provided on the upper surface of the solid polymer electrolyte membrane 3 on the side of the anode 7, and a catalyst layer 13 containing platinum (Pt) is provided on the lower surface of the solid polymer electrolyte membrane

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3 on the side of the cathode 11.

As best shown in Fig.1, a positive terminal 14 existing at one end of the anode 7 protrudes to the outside from one end face of the seal member 6. In the cathode 11, a negative terminal 15 existing at the other end opposite the positive terminal 14 protrudes to the outside from the other end face of the seal member 10.

The plurality of water electrolytic cells 2 are arranged, so that longer sides of the adjacent cells 2 are parallel to each other, and the positive terminals 14 (and the negative terminals 15) are disposed in a zigzag fashion. Thus, the anodes 7 of the water electrolytic cells 2 are disposed on one side, an upper on hypothetical plane, and the cathodes 11 are disposed on the other side, a lower hypothetical plane.

In this case, the number of water electrolytic cells 2 is an even number, and the positive terminal 14 of the water electrolytic cell 2 located on one of the outermost sides and the negative terminal 15 of the water electrolytic cell 2 located on the other outermost side are disposed on the same side and function as terminals for connection to a power supply. In the adjacent water electrolytic cells 2, at each end thereof, the upper positive terminal 14 and the corresponding lower negative terminal 15 are connected to each other through a conductive plate 16. Thus, the plurality of water electrolytic cells 2 are electrically connected in series to one another.

As clearly shown in Figs.2 and 3, first and second flow

path-defining flat box-shaped members 17 and 18 are disposed respectively above and below all of the water electrolytic cells 2 to sandwich these water electrolytic cells 2. The inside of the first flow path-defining member 17 functions as a flow path 19 for water and oxygen. The first flow path-defining member 17 has a water supply port 20 in one of sidewalls thereof and a water/oxygen discharge port 21 in the other sidewall. A plurality of openings 23 are formed in a bottom wall 22 of the member 17 to face the anodes 7, respectively, and each have a peripheral edge put into close contact with the seal member 6 of each of the anodes 7 in a sealing manner. Each of the anodes 7 has a plurality of elongated communication bores 24 which permit the communication between each of the openings 23 and the current collector 5 and thus the solid polymer electrolyte membrane 3. The communication bores 24 serve as water outlets and inlets and as oxygen outlets. The inside of the second flow path-defining member 18 functions as a hydrogen flow path 25 and has a hydrogen outlet 26 in one of sidewalls on the side where the water/oxygen discharge port 21 exists. A plurality of openings 28 are formed in a ceiling wall 27 to face the cathodes 11 and each have a peripheral edge put into close contact with the seal member 10 of each of the anodes 11 in a sealing manner. Each of the cathodes 11 has a plurality of communication bores 29 which permit the communication between each of the openings 28 and the current collector 9 and thus the solid polymer electrolyte membrane 3. Each of the

communication bores 29 is formed into an elongated shape, as are the communication bores 24 in the anode 7, and serves as a hydrogen outlet. Thus, the single water/oxygen flow path 19 and the single hydrogen flow path 25 are shared by the plurality of water electrolytic cells 2. This can provide the simplification of a flow path structure and an enhancement in flow path formability, as compared with a case where two types of independent flow paths 19 and 25 are provided in each of water electrolytic cells 2 so that the flow paths are connected together in series.

A panel-shaped solar cell 30 as a power supply is superposed onto an upper surface of the first flow path-defining member 17. A lead wire 31 from a positive terminal of the solar cell 30 is connected to the outermost positive terminal 14 of the water electrolytic apparatus 1, and a lead wire 32 from a negative terminal of the solar cell 30 is connected to the outermost negative terminal 15 of the water electrolytic apparatus 1.

If the water electrolytic apparatus is constructed as described above, an increase in electric current can be inhibited in the water electrolytic apparatus 1. In addition, the thickness of the water electrolytic apparatus 1 can be made substantially equal to that of each of the water electrolytic cells 2 and thus, the thinning of the apparatus 1 can be achieved. Therefore, if the water electrolytic apparatus 1 is superposed onto the panel-shaped solar cell 30, the height of the resulting

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assembly can be suppressed to a lower level.

During production of hydrogen, a reaction represented by $H_2O \rightarrow 2H^- + 1/2O_2 + 2e^-$ occurs on the side of the anode 7, and a transfer of protons is conducted in the solid polymer electrolyte membrane 3. Further, a reaction represented by $2H^+ + 2e^- \rightarrow H_2$ occurs on the side of the cathode 11.

A water electrolytic apparatus shown in Figs.4 and 5 includes a plurality of water electrolytic cells 2 developed all over a single flat plate 33. Each of the water electrolytic cells 2 has a first flow path defining member 17 including water and oxygen flow paths, and a second flow path defining member 18 including a hydrogen flow path. The water electrolytic cells 2 in first and third rows arranged in a left-to-right direction in Figs.4 and 5 are placed on the flat plate 33 with the first flow path-defining member 17 for water and oxygen located on an upper side and with the second flow path-defining member 18 for hydrogen placed on a lower side. On the other hand, the water electrolytic cells 2 in second and fourth rows are placed on the flat plate 33 with the second flow path-defining member 18 for hydrogen located on an upper side and with the first flow path-defining member 17 for water and oxygen placed on a lower side. The positive terminal 14 of the water electrolytic cell 2 at a left end of the first row and the negative terminal 15 of the water electrolytic cell 2 at a left end of the fourth row are connected to the power supply. In the water

electrolytic cells 2 in the first and second rows, the anodes 7 and the cathodes 11 are connected in series from the left end to the right end through conductors 34 in an order of the first row → the second row → the first row → the second row --- the second row. In the water electrolytic cells 2 in the third and fourth rows, the anodes 7 and the cathodes 11 are connected in series from the right end to the left end through conductors 35 in an order of the third row → the fourth row → the third row → the fourth row --- the fourth row. Further, the cathode 11 of the water electrolytic cell 2 at the right end of the second row and the anode 7 of the water electrolytic cell 2 at the right end of the third row are connected to each other through a conductor 36. Thus, the plurality of water electrolytic cells 2 are electrically connected in series to one another. The first flow path-defining members 17 in the water electrolytic cells 2 at the left ends of the first to fourth rows are connected to a water supply pipe 38 through conduits 37, and the first flow path-defining members 17 in the water electrolytic cells 2 at the right ends of the first to fourth rows are connected to a water/oxygen discharge pipe 40 through conduits 39. Further, the first flow path-defining members 17 of the adjacent water electrolytic cells 2 in each of the rows are connected to each other through a conduit 41.

The second flow path-defining members 18 of the water electrolytic cells 2 at the right ends of the first to fourth

rows are connected to a hydrogen discharge pipe 43 through conduits 42. Further, the second flow path-defining members 18 of the adjacent water electrolytic cells 2 in each of the rows are connected to each other through a conduit 44.

Although the embodiments of the present invention have been described in detail, it will be understood that the present invention is not limited to the above-described embodiments, and various modifications in design may be made without departing from the spirit and scope of the invention defined in claims.